A Systematic RFID Application Platform with Integration Capability for Tour and Exhibition

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Abstract—**Firstly, due to the characteristics of the tourist attractions, galleries and museums in China, a systematic RFID Application Platform for the tour and exhibition area is presented in this paper. This systematic RFID Application Platform can successfully support the implementation of four typical RFID application subsystems simultaneously. These four application subsystems can provide intelligent services respectively for four typical application fields which are ticket management, self-help navigation, visit route recording and tracing, as well as intensity monitor and guidance. Secondly, to make use of the existing resources as much as possible, say, make use of the existing animal information management system in the Beijing Zoo as much as possible, we present a mechanism for the systematic RFID Application Platform to integrate the existing systems to the systematic RFID Application Platform. This mechanism integrates the existing system to the systematic RFID Application Platform by using the Distributed Application Integration Framework. The data between the Platform and the existing system is exchanged via data share and exchange platforms (DXS、DXA). Lastly, we present a discussion of the implementation of the systematic RFID Application Platform, by taking the implementation of the platform in the Beijing Botanical Garden and the Beijing Zoo as two application instances. The open architecture of the systematic RFID Application Platform allows deployment of several applications and integration of existing sources of information.**

Keywords—RFID; integration; Distributed Application Integration Framework; application platform; tourism; exhibition; existing resources

I. INTRODUCTION

Information technology[1] plays a more and more important role in improving the country's competence over the tour and exhibition area. The Radio Frequency Identification (RFID) technology has been adopted by most of the research[2-10] in the tour and exhibition area not only to facilitate the intelligent service for tourist attractions, galleries and museums to satisfy visitors' requirement, but also the intelligent management of the tour and exhibition industry. As one of the most important application field of RFID technology, tour and exhibition has received fully attentions and supports.

Now, in the tour and exhibition area, paper tickets are used in most of the tourist attractions. But, the paper ticket is easy to be imitated and cause pollution. It is hard to achieve the intelligent management of the accessing of visitors by using the paper ticket. In order to optimize the existing management system, many tourist attractions begin to switch to the electronic tickets system. But, by using the electronic tickets system without the support of the location capability enabled discrete application or with the support of the location capability enabled discrete application alone, it is still difficult for the tourist attraction manage center to record and trace the movements of visitors, as well as to make the real-time monitoring to the distribution of the tourist's intensity and provide guiding in time. Thus it is necessary to design a systematic application platform which consists of more than one discrete application to provide more resolutions. Moreover, although the introduction board and card are widely used by tourist attractions to intrigue the interests of the tourist, the information of tour attractions and exhibitions the tourist can get is so limited. They can hardly be attracted. Therefore, it is necessary to provide a personalized and interactive multimedia information exhibition service to enable the visitor to get enough information they desire.

With the supports of the RFID technology, the intelligent service of the tour and exhibition area has gained a lot of improvements in the countries. In Europe, America and China, there already exist some discrete applications of the RFID technology for the tourist attractions, galleries and museums. However, theses discrete applications don't tend to provide a systematic service resolution to the tour and exhibition area, but rather focus on providing one particular service mostly.

In Europe and America ([2][5][6]), the United States Snö Mountain ski has used RFID smart wristbands to identify the workers, tourists and rentable ski equipment. The Apenheul Primate Park, Netherlands, has begun to distribute the backpack to visitors with RFID tags embedded in. By embedding the RFID tag in backpacks, the location and the

This work was supported by the National Natural Science Foundation of China grants U0935002/L05 and National High-Tech Research and Development Program of China (863) grants 2008AA04A108 and 2008AA04A110.

time information about the passenger who is taking the backpack could be collected by the RFID system. Then the detail of the number, the movement and the other information of the passenger at the park could be obtained by the RFID application to help the manager determine where, when and why some congests occurred, so as to handle the congestion pressure well.

In China, the application of the RFID technology in the tour and exhibition area has just started, say, [7][8]. There mainly exist some discrete application cases which mostly focus on the management of tickets, e.g., the RFID technology supported e-tickets has been applied in the Mount with the fingerprint device and the RFID technology supported electric guide has been adopted in Jiuhua Mountain. In the case of the RFID application in the Mount, the visitor could temporarily leave the tourist attraction without having to pay for another ticket when he/she comes back, as long as he/she had loaded his/her fingerprint before he/she left the Mount. In the case of the RFID application in the Jiuhua Mountain, the electric guide, which is as big as a cigarette case, is used. The professional introduction of the spot where the tourist reached at could be heard by him/her automatically by using the electric guide, after the electric guide has received the signal sent from the RF device installed at the spot. The electric guide not only could contain the brief introduction of the main scenes, but also could provide services to visitors in three different languages, include Mandarin, English and Korean.

Based on the analysis given above, most of existing RFID applications used for intelligent services and intelligent managements in the tour and exhibition area are still discrete applications. Most of them are focus on providing one particular service. Therefore, a systematic RFID application platform is needed to support and organize the discrete applications, based on the characteristic of the countries in the tour and exhibition area. The systematic RFID application platform should be used to provide more intelligent services by using more than one discrete RFID application. The interacting among the discrete applications could promote the development of the RFID applications in the tour and exhibition area in the countries in future.

In this paper, a systematic RFID Application Platform with integration capability for the tour and exhibition area will be presented. For the utilization of the existing resources should be taken into consideration. The platform will support four RFID application subsystems which are given based on the characteristics of China. As in China, the intelligent service should be provided with the consideration of the overwhelmed population problem. The open architecture of the systematic RFID Application Platform allows deployment of several applications and integration of existing sources of information.

The rest of the paper is organized as follows. Section II presents four RFID application subsystems based on the analysis of the existing problem and requirement in the tour and exhibition area in China. In order to systematically promote the development of the information industry with the RFID technology in the tour and exhibition area, we present a systematic RFID Application Platform in Section III. To make use of the existing resources as much as possible, it is necessary to integrate the existing information system to the systematic RFID Application Platform. So a mechanism is adopted by the systematic RFID Application Platform to implement the integration to make use of the existing resources as much as possible. The mechanism is presented in Section IV, which could make a best use of the existing resources. Section V presents a discussion of implementation of the systematic RFID Application Platform. Some benefits of this work and some future work are listed in Section VI. We will draw the relevant conclusions in Section VII.

II. THE PRIORITY OF THE RFID THECHNOLOGY IN TOUR AND EXHIBITION AREA

With the rapid growth of economy, the information technology begins to determine the development of the tour and exhibition area, especially the intelligent service and management. In order to organize the existing discrete applications and promote the development of the RFID application systematically, in this section, there are four typical application subsystems be concluded from four typical application aspects, according to the investigation into tourist attractions, galleries and museums in China.

A. Ticket Management

At present, the paper ticket is still the main paper bill used in the tourist attraction in China, which will be invalid after checking in. Although the paper ticket has the privilege to save costs directly, it is easy to be imitated, copy, apply human favor (to someone by offering free check in) and do substitutions admission. It could make a serious loss of ticket revenue for the tourist attraction afterwards. Moreover, using the paper ticket could make statistical analysis and computer management of the visitor accessing difficult.

To solve the above problems caused by using paper ticket, most of tourist attractions have started to use e-ticket in China. But, the e-ticket cannot fully satisfy the requirement of new recreational facilities before the RFID technology being developed. As the development of the RFID technology, the RFID ticket begins to become the most advanced non-contact electronic tickets which are made by embedding the RFID tag in some special media, say, tickets. In the future, some additional services should be added to the e-ticket system, such as take buses in the tour attractions by e-ticket, pay for dinner in the restaurant by the e-ticket and so on.

Thus, with the support of the RFID ticket, we systematically concluded an intelligent RFID-based ticket management subsystem, which can achieve tickets management, tickets inspection, tickets recharging (include tickets refunding and returning tickets back), expending in the restaurant/tour or on bus taking, and incoming statistics. The function module structure is shown in Figure 1. The subsystem supports the flexible adding of the function modules by reserving interface for them.

B. Self-help Navigation

At present, guides and electronic devices are used generally to help the tourist to travel in tour attractions in China. But, to the individual visitor or families, the charge of employing a guide is too expensive. The electronic devices would explain

the attraction, only if the visitor has selected right. As a result, there are always some visitors who use the electric device complain about missing some scenes to visit. What's more, the electric device may bring another trouble when there are new scene explanations or features need to add in. When there are new explanations and features need to add in, the electric equipment chip should be refreshed, the workload of which is very large to medium-sized tour attractions.

To solve the problems in the navigation, we intend to introduce visitors to attractions around the tour attraction based with the RFID technology and conclude an intelligent RFID-based personalized scene introduction subsystem as the second typical application subsystem. The system can implement the reader renting and collection, language selection and browsing option, humanized scene information display and guide information display. The function module structure is shown in Figure 1. The subsystem supports the flexible adding of the function modules by reserving interface for them.

C. *Visit Route Recording and Tracing*

The visit route is significant for both the visitor and the manger in tourist attractions, galleries and museums. In China, the population is overwhelmed. There should be an application system to provide the recording and tracing of the visit route. To the individual visitor, the application system should be able to enable the real time requirement of the status of the visitor and locate the visitor's location right now by recording and tracing the visit route of the visitor. To the visit group, it can provide the recording and tracing of the group's visit route. While, to the manager of the tourist attraction, the choice and the preference of the tourist to the scene of the tour attraction should be able to be mined, thus present a decision support for the manager to do better spot organization and project arrangement of tour attractions, galleries and museums through the visit route analysis.

Based on the discussion shown above, the third typical application subsystem is proposed as an intelligent RFID-based visit route recording and tracing subsystem. It can support binding the ticket to the visitor, visit track information collection, visit routes tracing and inquiring, visit routes analysis and route map display. The function module structure is shown in Figure 1. The subsystem supports the flexible adding of the function modules by reserving interface for them.

D. *Intensity Monitoring and Guidance*

In this paper, intensity is defined as the total number of tourists in particular place, such as a path, an attraction, a venue and so on. Because of the great population in China, it is necessary to monitor the capacity status of tourist attractions to release the status of the passenger flow and achieve the control of the flow immediately. [3] proposes a framework for group tour guiding services based on RFID and wireless sensor network which can maintain a communication group among passengers. But the current method to monitor and control the passenger flow is mainly based on hand counting or the paper tickets statistics. It is hard to maintain a high quality monitoring result of the passenger flow.

In order to provide a high quality intensity monitoring and guidance service in China, we intend to apply an intelligent RFID-based intensity monitoring and guidance subsystem as the fourth typical application. Base on the intelligent RFID-based ticket management subsystem, this subsystem can be combined with the location ability of the RFID technology to achieve the real time passenger number monitoring, one specific area's passenger number statistics, intensity analysis, map display and inquiry, visit track analysis and so on. The function module structure is shown in Figure 1. The subsystem supports the flexible adding of the function modules by reserving interface for them.

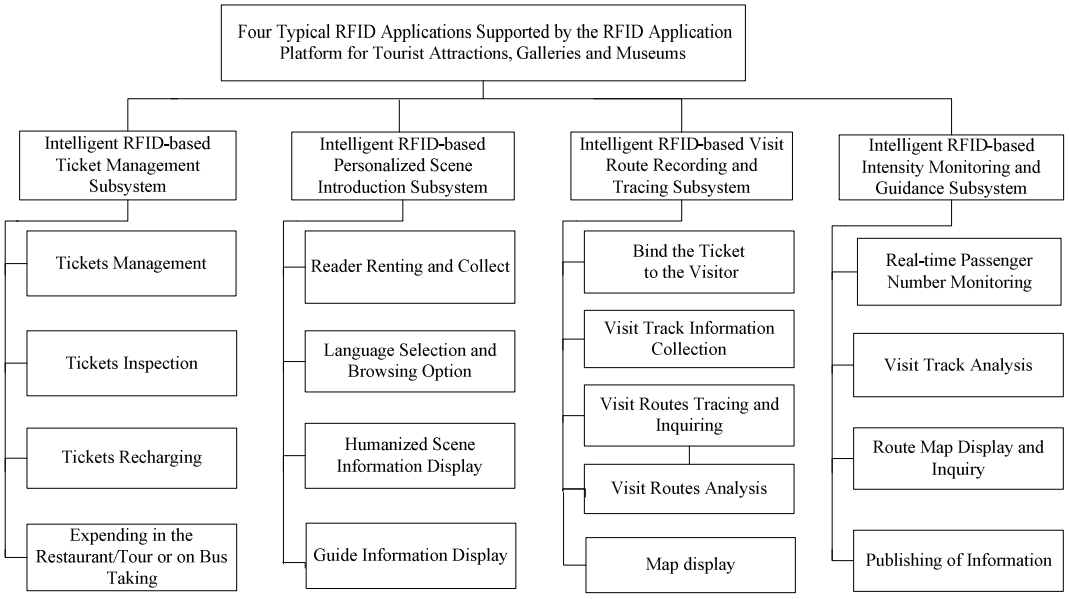

Figure1 Four Typical RFID Application Supported by the systematic RFID Application Platform

III. SYSTEMATIC RFID APPLICATION PLATFORM FOR THE TOUR AND EXHIBITION AREA

In order to implement the intelligent RFID-based ticket management subsystem, intelligent RFID based personalized scene introduction subsystem, intelligent RFID based visit route recording and tracing subsystem, and the intelligent RFID-based intensity monitoring and guidance subsystem analyzed in Section II, we present a systematic RFID Application Platform for the tour and exhibition area. It well respects the management pattern of the tour and exhibition industry in China. The systematic RFID Application Platform gives a full consideration to the system's high availability, usability, maintainability, advancement, scalability and security et al..

A. The Systematic RFID Application Platform

The systematic RFID Application Platform for the tour and exhibition area is designed on a multi-level architecture using both the C/S and B/S patterns. The architecture designed for the platform is shown as Figure 2. Four typical application subsystems are contained at the Application Layer as four typical RFID applications. They are intelligent RFID-based ticket management, intelligent RFID-based personalized scene introduction, intelligent RFID-based visit route recording and tracing, and the intelligent RFID-based intensity monitoring and guidance.

When the systematic RFID Application Platform is put into use, a new issue about the utilization of the existing resources emerges. It is practicable method for the systematic RFID Application Platform to use the data maintained in the existing system by integrating the existing system to the systematic RFID Application Platform. Thus, to make use of the existing resources as much as possible, it is necessary to integrate the existing information system to the systematic RFID Application Platform. A mechanism is proposed in the Section IV for the systematic RFID Application Platform. The mechanism can be used to integrating the existing system to the systematic RFID Application Platform, as a result, to make use of the existing resources as much as possible.

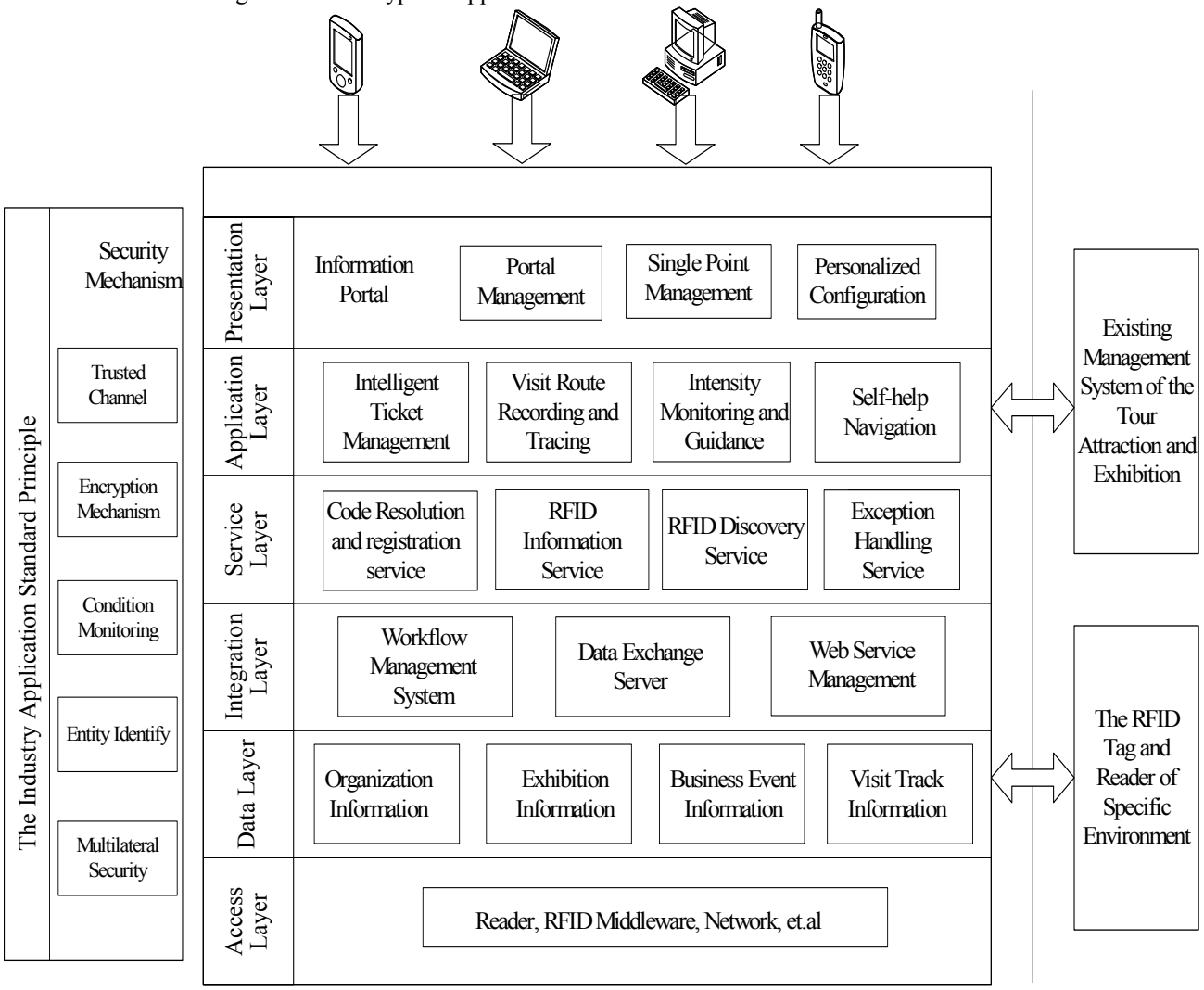

Figure 2 The Architecture Designed for the Platform

B. *The Multi-level Architecture for the Systematic RFID Application Platform*

The systematic RFID Application Platform is designed according a multi-level architecture. The architecture includes the access layer, data layer, integration layer, service layer, application layer, and presentation layer from down to up.

1) Access Layer consists of the RFID Reader, middleware and network, which is designed to do the RFID tag data collection, filtering and grouping for the upper layer.

2) Data Layer consists of the business data, such as the organization information, the exhibition information and the visit track information.

3) Integration Layer consists of the data integration mechanism and the process integration mechanism. Under the support of the two mechanisms, the existing information system could be integrated to the proposed systematic RFID Application Platform well. And the data integration mechanism is provided according the Distributed Application Integration Framework.

a) Data Integration Mechanism (could also be called data exchange platform) is the basis for the exchanging and sharing of the inner information on the systematic RFID Application Platform. The data integration mechanism can support the integration of various heterogeneous data by publish and subscribe mechanisms.

b) Process integration mechanism (could also be called workflow management system) could implement the management of the procedure inner or inter the applications based on the Petri Net by the workflow engine.

4) Service layer consists of the RFID service provided by the systematic RFID Application Platform. It could be constructed by RFID code resolution service, RFID discover service, RFID information service and so on.

5) Application layer consists of various RFID applications, which is built up on the lower layers for the tour and exhibition area. There are four typical applications proposed in this paper. The four typical appliations are intelligent RFID-based ticket management, intelligent RFID-based personalized scene introduction, intelligent RFID-based visit route recording and tracing, and the intelligent RFID-based intensity monitoring and guidance.

6) Presentation layer is the single entry for the user to access various service or information. It aims to share application resources and informations, achieve the centralized information access by making an information management center rather than by the "portal". Thus it can enable the users to interoperate with the person, the information content, the application and the procedure personalizely, securely and with single-sign-on.

7) From the aspect of the safety, security and the safe management, the systematic RFID Application Platform is also armed with the trusted channel, encryption mechanism, condition monitoring, entity identify and multilateral security mechanisms.

The multi-level architecture of the systematic RFID Application Platform is practicable. It enables the complex systematic RFID Application Platform to be packaged layer by layer and alleviate both design and development difficulties.

Based on the analysis in Section II, the four typical application and some of their function modules supported by the systematic RFID Application Platform is shown in Figure 2. The function modules could be added through the reserved interface.

IV. INTEGRATE THE EXISTING MANAGEMENT SYSTEM TO THE SYSTEMATIC RFID APPLICATION PLATFORM

After many years' development, the business system in the tour and exhibition area has become relatively mature in China. As the legacy of the tour and exhibition area, the business system should be connected and integrated into the systematic RFID Application Platform to maximum the utilization of the existing resources of the system. This Section will present a mechanism to make the best use of the existing business resources. It should be able to make use of the existing resources as much as possible, say, make use of the existing animal information as much as possible in the Beijing Zoo case which is presented in Section V.

In order to solve the implementation of integrating the systematic RFID Application Platform to the existing system, we decided to design a Distributed Application Integration Framework, and use the data sharing and Data Exchange Platform (DXS, DXA) to do data exchange. The mechanism will be discussed in this Section.

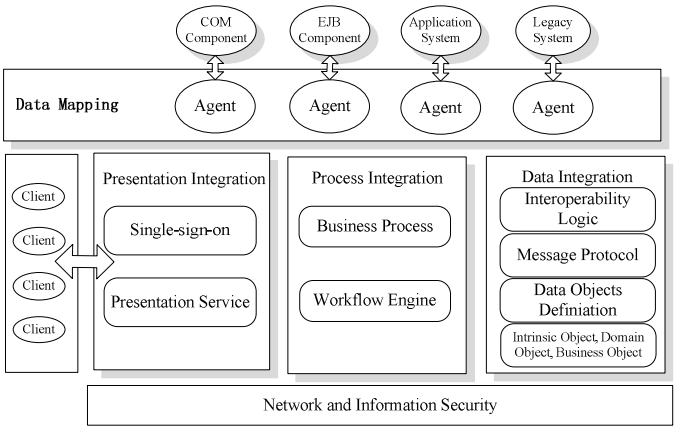

Figure 3 Distribute Application Integration Framework

The Distributed Application Integration Framework used by the systematic RFID Application Platform is shown in Figure 3. There are Data Integration Layer, Process Integration Layer and Presentation Layer in the Distributed Application Integration Framework. The data exchange function is implemented by the Data Share and Exchange Platform.

A. *Data Integration Layer*

At the integration layer, the data to be exchanged is packaged into the data object by the data exchange server and application adaptor. The interoperation and integration between application systems are implemented by using the Publish/Subscribe and the Request/Response communication

pattern. Both the Publish/Subscribe and the Request/Response communication pattern are supported by the message mechanism.

B. Process Integration Layer

The process integration is implemented with the workflow technology. The workflow is mainly used to configure, implement and monitor business processes. We develop a workflow management system based on the Petri net, as shown in Figure 4. There are three layers in this system, which are process logic layer, process semantic layer and process execution layer. The process logic is described by the synchronous distance. The process semantic is described by the C_Net. The process execution layer is implemented by adding amount of manage rules in the library.

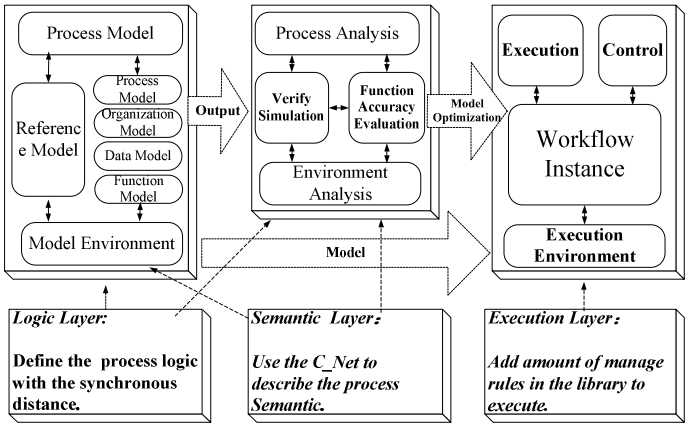

Figure4 Workflow Management System Based on Petri Net

C. Presentation Integration Layer

Through the presentation mechanism provided by the portal server at the Presentation Integration Layer, the user could get a comprehensive view of information and business. After being identified as a legal user by the identifier, the user could transfer from one system to another seamlessly according to the limited authority. What's more, the user could inquire, share and publish information transparently.

To implement the data exchange, a data sharing and exchanging platform is needed. The data sharing and exchanging platform consists of the data exchange server (DX-Server, DXS in short) and the data share adaptor (DX-Adaptor, DXA in short). The DXS architecture is shown as Figure 5. The data object created by the application is transferred into the pre-decided format by the DXA. Then, before being sent out to the DXS by the forward thread, the transferred data object will be put in the forwarding queue.

After the subscriber has sent out the subscription information, the subscription information adaptor will change the information into the XML format which is recognizable to the DXS before sending out it. When the DXS receives the event published by the publisher, the DXS will create a match thread. If the event matches the user's subscription, the system will write in the forwarding database the event right matched.

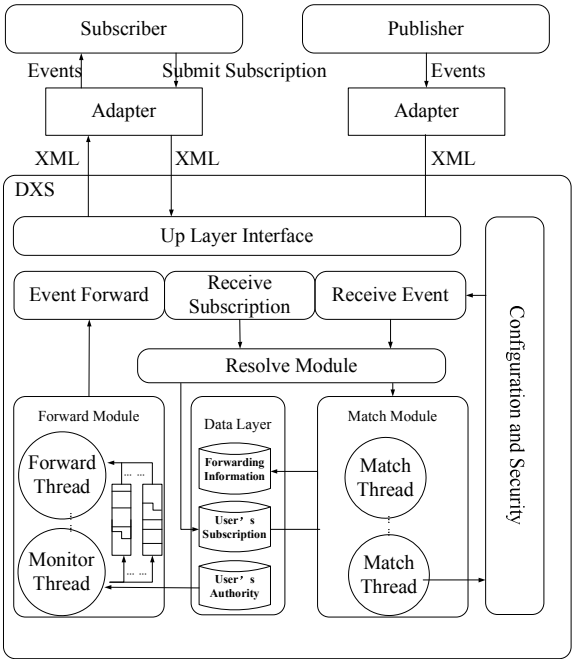

Figure 5 DXS Architecture

V. IMPLEMENTATION

The implementation of this systematic RFID Application Platform is more complex than the implementation of the discrete RFID application. In this section, the deployment of the systematic RFID Application Platform in the Beijing Botanical Garden and Beijing Zoo is investigated and analyzed.

The deployment of the systematic RFID Application Platform in Beijing Zoo is a little more complex than in the Beijing Botanical Garden. In the case of the Beijing Zoo, the information resources the existing system maintained are needed by the implementation of this systematic RFID Application Platform. To make use of the existing system as much as possible, the Distributed Application Integration Framework is adopted by the systematic RFID Application Platform.

The deployment of the systematic RFID Application Platform is same in both the Beijing Botanical Garden Deployment and the Beijing Zoo. The complete deployment of the systematic RFID Application Platform is shown in Figure 6.

A. Beijing Botanical Garden Deployment

The Gigabit Fiber Ethernet is deployed in the tourist attraction. The wireless gateway will be deployed at the important spot and the transport route. The data collection and upload for the systematic RFID Application Platform will be able to be implemented then. In order to improve the performance of the Botanical Garden's network system, the network core should adopt the modulated switch to achieve high backplane and high bandwidth. Then the server and the RFID reader can interoperate on high bandwidth. In terms of reliability, the workload balance device will be settled in the inner network of the garden to avoid the single point failure in the management center. In terms of maintainability, the host monitoring software will be used to achieve the real-time

online of the real-time server, as well as the update of the RFID reader software and the information management of the application's tracking and bug reports, et al.. In order to achieve the integration between the data exchange and the business process, the tourist attractions should be interconnected by the Internet/Intranet as well as the tourist attractions and the up departments.

As in the tourist season, a large number of business data will be produced, the connection between servers is built through SAN storage network based on the optical path as the basis.

The municipal management unit will take charge of many sub tourist attractions. The municipal management center and the sub tourist attractions will achieve the integration grade by grade. Each tourist attraction will have a unified database. The database and the application will be deployed in the center node of the tourist attraction.

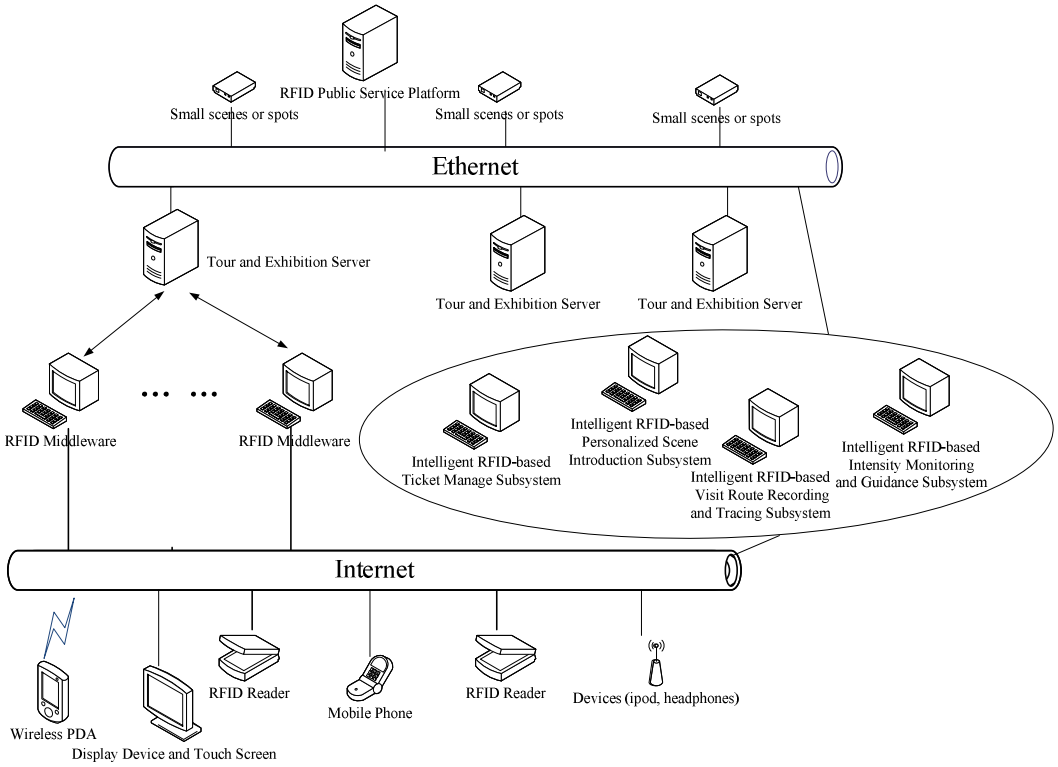

Figure6 Complete Deployment

B. Beijing Zoo Deployment

The information resources the existing system maintained are needed by the implementation of this systematic RFID Application Platform for most of the time, like in the Beijing Zoo.

In the case of the Beijing Zoo, the animal information and the detail information of the animal is maintained in the animal information management system. The Distributed Application Integration Framework presented in Section IV should be implemented to make the existing animal information management system be integrated to the systematic RFID Application Platform. It can make use of the animal information maintained in the existing animal information management system as much as possible.

The deployment of the systematic RFID Application Platform in the Beijing Zoo is the same as in the Beijing Botanical Garden. But after the deployment, the Distributed Application Integration Framework should be used to integrate the existing system to the systematic RFID Application Platform.

To use the existing animal information maintained in the existing system on the systematic RFID Application Platform, the existing system could be connected with the systematic RFID Application Platform by adaptor. Here, we take the implementation of the self-help navigation function as an instance. When the visitor send the tag EPC of the animal to the Platform, the data exchange server at the Platform will index the relative information by the received EPC. The relative information is stored in the animal information management system database server. The relative information indexed from the database server will be sent back to the visitor.

VI. BENEFITS AND FUTURE WORKS

In this section we will summarize the benefits of the systematic RFID Application Platform and list some difficult works for the future.

A. The Benefits

1) The systematic RFID Application Platform for tour and exhibition includes both C/S and B/S patterns, which takes the high availability, scalability and security into consideration. The adoption of both unify database and hierarchical integration patterns will makes up for each other's deficiencies.

2) There are four typical applications were concluded. The four typical applications are implemented as four subsystems for the systematic RFID Application Platform, which are intelligent RFID-based ticket management subsystem, intelligent RFID based personalized scene introduction subsystem, intelligent RFID based visit route recording and tracing subsystem and the intelligent RFID-based intensity monitoring and guidance subsystem.

3) It solves the problem of integrating the existing system into the RFID Appliation Platform by using of the Distributed Application Integration Framework and achieve the data exchange with data sharing and the data exchanging platforms(DXS, DXA).

B. Difficulties

To the systematic RFID Application Platform, the difficult work includes 1) the security and the dependability, 2) the integrate management of a large number of hardware devices.

To the integration, the difficulty work includes 1) the construct of the data exchange information model and the relevant standards, 2) the solution to the problem of the security, stability and transmission speed of the information transfer.

VII. CONCLUSION

After the analysis of tourist attractions, galleries and museums in China, we present a systematic RFID Application Platform for the tour and exhibition area and give a discussion about the specific implementation afterwards.

This paper presents a complex architecture for the integration of several applications for touristic attractions. This systematic RFID Application Platform can successfully support the implementation of four typical RFID application subsystems at the same time.

In order to make use of the existing resources as much as possible, we proposed a mechanism for the systematic RFID Application Platform to integrate the existing business system to the systematic RFID Application Platform. The mechanism includes of designing a Distributed Application Integration Framework, and using the data sharing and Data Exchange Platform (DXS, DXA) to do data exchange. The proposed systematic RFID Application Platform with integration capability can systematically achieve the integration between the existing business system and the Platform.

And the systematic RFID Application Platform could be used to provide more intelligent information services by more than one discrete RFID application.

By presenting an open architecture which allows deployment of several applications and integration of existing sources of information, we look forward a flexible RFID Application Platform to be used in more fields in the future. Its flexibility will not only support the integration of various applications for one particular field, but also make use of the existing resources well. And the interacting among the discrete applications could promote the development of the RFID applications in the tour and exhibition area of the countries in the future.

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